APPENDIX VIII. TOOLING AND PRODUCTION PLANNING

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A. Introduction

As the design of the Doubler magnet has evolved, the way in which the components could be economically fabricated has always warranted prime consideration. For instance, the nesting of stamped laminations to minimize material usage was thoroughly explored. The 22-ft length of magnet was partly selected on the available stacking fixtures, maximum conductor length, tube lengths available, and edge-iron lengths available.

B. Tooling

The design of tooling was based upon the short-run needs to prove the concept being explored and the long-term requirements to build 1000 22-ft magnets. The initial tools used usually were adaptable to modification to meet the high-speed requirements of future production.

Coils. The general design of the coils has been fixed for some time and therefore the level of production tooling has developed to the greatest extent. Normal coil winding is done on a rotating table upon which a coil-winding mandrel is mounted. With a 22-ft magnet, the floor space required for such a machine is considerable. In order to meet the production requirements, a bank of these machines will be required. Therefore, a concept of winding was devised that requires much less floor space. The mandrel is stationary and the reel of conductor "walks" around the mandrel. This concept has the further advantage of allowing very rapid traversing along the length and slowing up only at the ends where shaping of the coil is more difficult. To accomplish this, the mandrel oscillates about its longitudinal axis while the conductor is coming around the ends. The winding operation is shown in Fig. VIII-1.

After winding, the coil is "packaged" and molded into a rigid component to place each conductor permanently to its correct position within a few mils. This is done by precision molds and extremely high packaging pressure (approximately 10,000 psi). For initial production, these molds are closed with heavy high-

strength bolts, but the design provides for conversion to hydraulics for final high-speed production. Figure VIII-2 shows the important "packaging" of the coil, which places the conductor near its final position in preparation for the application of the high pressure.

Final Assembly. The finished coils are assembled together onto a mandrel and the coil-clamping half rings are pressed on in an interleaving manner to form a solid laminated shell to support the coil. Currently this is mainly a hand operation, with the use of special hand tools to make it a reasonably fast operation (approximately 1 ft per hour). As the exact design of these collars becomes frozen, automated equipment for coating, stacking, and meshing will be acquired that should reduce this time to a fraction of its present value.

Compressing the laminated shell to support the coil assembly tightly also requires high pressure in order to provide intimate contact with the coil. Hydraulic rams provide this pressure, whereas bolted construction holds the pressure during the curing cycle. For final high-speed production, hydraulic rams could be provided for the entire length of each magnet and held during the cure cycle, thus further speeding the operation.

C. Production Planning

In addition to perfecting the tooling for production, space is being provided. The Magnet Facility, which consisted of two large industrial buildings used for the fabrication of the original Main-Ring magnets, has now expanded into a third building. Two of these buildings are planned to be used exclusively for the Energy-Doubler fabrication project. The third building is primarily for conventional-magnet fabrication, but also houses the fabrication of the magnet yokes. These areas are separated and are being partitioned according to the cleanliness and criticality of the various operations. The coil-winding itself, up to the stage of the initial cure, is the most critical from the standpoint of contamination with dirt and chips. This area is therefore being prepared for the highest level of cleanliness.

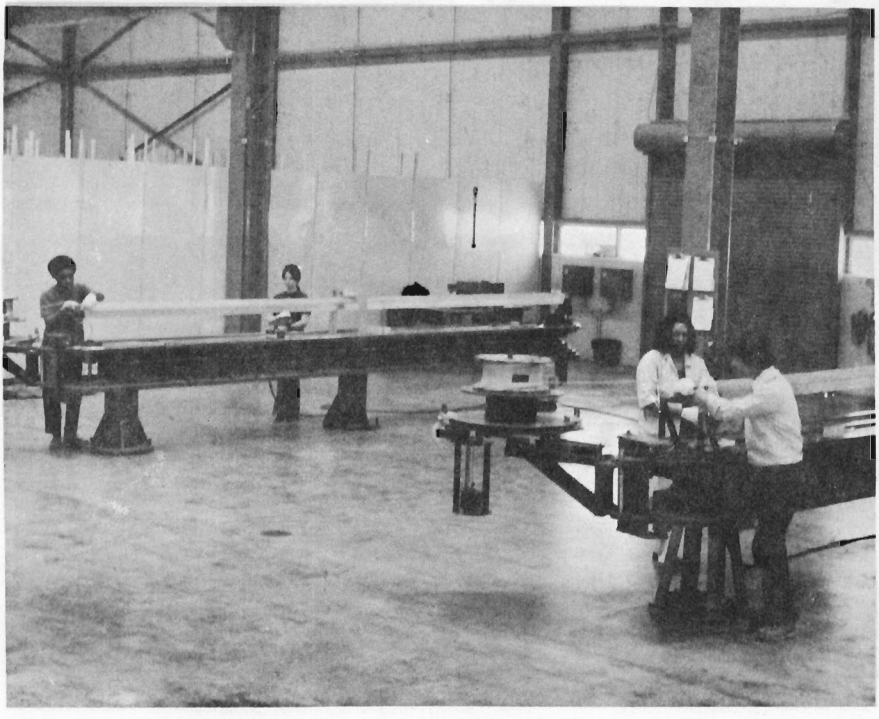

Fig. VIII-1. Winding the 22-ft magnet.

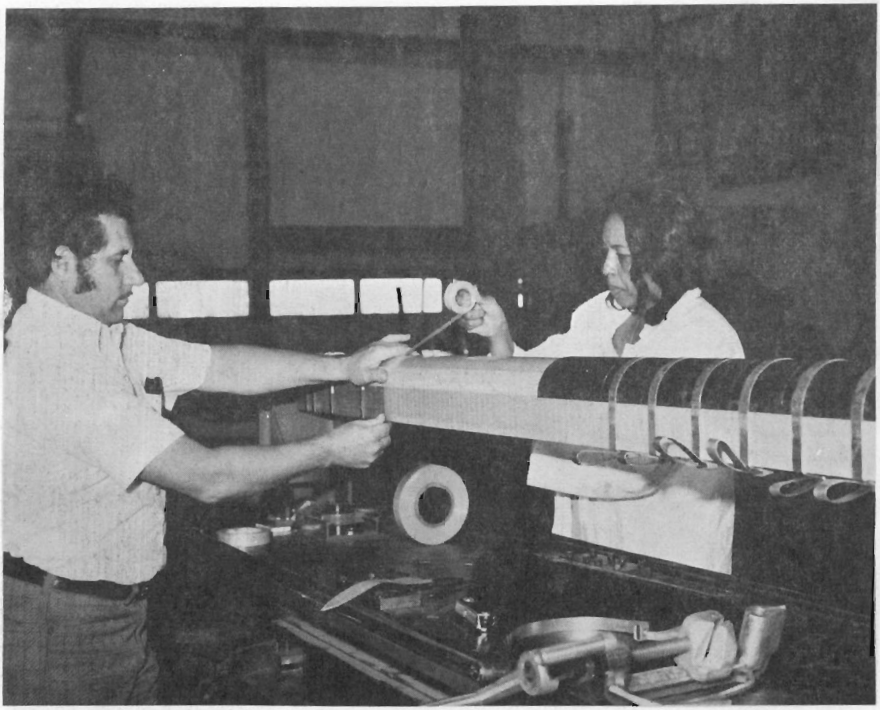

Fig. VIII-2. Packaging of the coil.